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Quark susceptibilities, transport properties and heavy quark production in an extended Quasi-Particle Model with $N_f = 2+1+1$ flavors

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The quark susceptibilities are a very useful tool to understand the nature
of the degrees of freedom in the vicinity of the QCD phase transition while Heavy-Quarks (HQs) transport coefficients give us information on their thermalization time in the Quark-Gluon Plasma (QGP). Recently, new lattice results for the equation of state of QCD with $2+1+1$ dynamical flavors have become available. Therefore, we extend our QPM approach for $N_f = 2+1$ to $N_f = 2+1+1$ where the charm quark is included. We also explore the extension of QPM approach to a more realistic model in which partonic propagators explicitly depend on the three-momentum with respect to the partonic matter at rest in order to match pQCD at high momenta following Dyson-Schwinger studies in the vacuum. In this context, we evaluate and correctly reproduce both EoS and quark susceptibilities which are understimated in the simple QPM approach. Therefore, we study the impact of the extended QPM approach on both the transport coefficient and the spatial diffusion coefficient D_s of charm quark making a comparison with the results in the standard QPM approach. The D_s for the extended QPM is modified when $T/T_c \leq 2$ due to the enhancement of the $g(T)$ at low temperatures which corresponds to a decrease of the D_s coefficient. This means that QPM describes a strong non-perturbative behaviour near to T_c similar to the one achieved in strongly coupled theory as AdS/CFT while in the high T region the D_s reaches the pQCD limit quickly than the standard QPM. An explicit treatment of the moment dependence of quasi-particle masses and coupling has been often postponed, but it significantly affects
the p dependence of R_{AA},v_2, v_3. Given the new upgrade of ALICE and CMS will allow to access low p_T obsevarbles with high precision,
the corresponding development of the QPM approach employed for realistic simulation is a necessary step toward a more solid and precise determination of D_s.\\\\

[1] M.L.Sambataro, S.Plumari and V.Greco, Eur. Phys. J. C 80, no.12, 1140 (2020).\\

[2] M.L.Sambataro et al., in preparation.

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